

Article

Optimal Body Composition and Anthropometric Profile of World-Class Beach Handball Players by Playing Positions

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Abstract: Profiling of beach handball players is required to optimize sports performance, talent identification, and injury prevention. The study aimed to describe the anthropometric characteristics, somatotype, and body composition of elite male and female beach handball players classified by playing positions. Thirty elite beach handball players (15 male, 15 female) of the Spanish National Beach Handball Team, which ranked fifth and first in the VII World Championships, respectively, were categorized as front (wings/specialists), back (pivots/defenders) players and goalkeepers. Independent from position, male players showed larger values of anthropometric characteristics, girths, breadths, and absolute components of body composition than female players. Contrastingly, skinfolds, and body fat mass percentage were higher in female players. All these results were statistically significant ($p < 0.05$) with large to extremely large effect sizes ($d = 1.4$ – 5.4). The position-related differences indicated that male back players were taller ($p = 0.008$; $\eta_p^2 = 0.56$), heavier ($p = 0.016$; $\eta_p^2 = 0.50$) and showed larger arm span ($p = 0.036$; $\eta_p^2 = 0.42$) than front players. In contrast, female goalkeepers showed larger body mass ($p = 0.007$; $\eta_p^2 = 0.57$) and BMI ($p = 0.035$; $\eta_p^2 = 0.43$), whereas back players showed higher muscular mass than goalkeepers ($p = 0.022$; $\eta_p^2 = 0.47$). The present study provides anthropometric reference values of elite beach handball players, and indicates differences between playing positions, providing normative data for talent identification of male and female players.

Keywords: team sports; fat mass; muscle mass; elite players; positional differences; sand; talent identification

1. Introduction

Beach handball emerged as a sport derived from team handball with distinctive rules and a sandy playing surface. In recent years, beach handball has become increasingly popular thanks to the support of various bodies, such as the International Handball Federation and the International Olympic Committee. As a result of this popularity, the first International Handball Federation (IHF) Beach Handball World Championships was organized in 2004 on a biannual basis. Since then, the IHF has also organized indoor youth, junior and senior World Championships, as well as Asian, European, Oceania, and Pan American Championships. Additionally, beach handball is played in national leagues from more than 50 countries. In 2018, the last world tournament was the Beach Handball World Championships (Kazan, Russia). From 30 June to 5 July 2020, the Beach Handball World Championships has recently taken place in Pescara, Italy, with 400 athletes from 32 teams and 22 nations from the five continents. As beach handball continues to grow in popularity, it is now being considered to debut as a separate event in the 2024 Olympic Games, as a step towards becoming an

Olympic sport. For the above reasons, beach handball can be regarded as a sport with a huge impact among coaches, participants, and spectators.

Beach handball and team handball share motor characteristics such as accelerations, sprints or jumps, as well as rapid changes of direction and a high number of physical collisions [1–5]. The intense and intermittent nature of the two variants of the sport suggests that handball players must be able to develop high values of maximum strength and muscle power in both upper and lower limbs [6], so muscle mass, and therefore body composition, are factors in fitness and success [7–10]. Along with body mass, other anthropometric characteristics have been shown crucial for sporting action and performance in handball [11–13] and other typical team sports such as volleyball, soccer and rugby [14]. For instance, throwing, as the most important technical action in handball players performance [1,15,16], depends on the ability of the arm to reach sufficient acceleration so that the ball leaves the hand at maximum possible speed. The duration of the throwing movement reduces the visual information available to the goalkeeper and the speed of the ball is related to the time for the goalkeeper to save a goal [17]. As a result, bigger body size in terms of fat-free mass and pertinent anthropometrics have positive effects on throwing performance. For instance, increased hand spread helps firm ball grip [13,16]. Besides, the knowledge of anthropometric body measures is of paramount importance for successful talent identification programs as it fulfills four of the five requirements identified by Ackland [18]: (a) recording a set of data of each athlete, (b) gathering a set of normative data, (c) using these data to construct profiles of athletes, and (d) interpreting such profiles to guide the selection process or provide the basis for an ongoing training program. Therefore, anthropometric profile and somatotype give valuable information about handball players' physical condition and allow coaches to identify talent, select players and provide appropriate training volumes and intensities to increase their capabilities.

The anthropometric profile of team handball players has been widely reported in the literature [3,15,19–24], where reference values were used for player identification and selection criteria. However, despite the growth of beach handball at a participatory and organizational level in recent years, the only studies addressing the anthropometric profile of beach handball players have focused on elite female players with no indication of playing position [10,25,26]. Therefore, there is no information available about the variation of anthropometric characteristics by gender and playing positions in elite beach handball players. The comparison between male and female players would provide evidence of the differences between beach handball teams, especially for top-level elite players. Despite variations between genders are expected, to the knowledge of the authors, there is no literature addressing them in a beach handball elite sample. In the field of sports anthropometry, the comparison between male and female helps to understand the variation in specific characteristics for elite [27] and non-elite players [28]. Similarly, to our best knowledge, there are no studies indicating the differences and the distinctive pattern between playing positions in beach handball. Thus, there is not enough evidence of anthropometric characteristics by playing positions in this discipline as with team handball [29,30]. An anthropometric analysis of male and female players' profile would help in identifying talent and optimizing the strength and conditioning training programs for each playing position [2,22,31].

Therefore, this study aims to provide anthropometric reference framework for elite beach handball players and explore how these parameters differ between gender and between playing positions. To this effect, we carried out a comparative analysis of the anthropometric profile, somatotype and body composition by playing position of male and female elite beach handball players of the Spanish national team. This quality sample comprises the entire Spanish National Beach Handball Team competing at international level in World Championships.

2. Materials and Methods

2.1. Subjects

The study sample was composed of 15 male and 15 female elite beach handball players participating in the Annual Spanish Beach Handball Cup. They all were professional players belonging to the National Beach Handball Team of the Royal Spanish Handball Federation which ranked fifth (male) and first (female) in the World Championships. This sample represented the population of Spanish male and female international elite players. Players were categorized as front players (wings and specialists), back players (pivots and defenders) and goalkeepers, according to position-specific playing demands. Subjects were instructed to conduct normal dietary habits and report to the measurement tent in a fully hydrated state. All participants were previously informed about the objectives of the research, the experimental protocol and the procedures of the study and voluntarily gave written informed consent to participate in the study in accordance with the Declaration of Helsinki.

2.2. Anthropometric Data

Anthropometric measurements were performed following standard protocols adopted by the International Society for the Advancement of Kinanthropometry (ISAK) [32]. All measurements were taken in basal conditions, in the same tent, at ambient temperature (22 ± 1 °C), and by the same researcher who was an accredited Level 2 anthropometrist of ISAK. Technical measurement error was lower than 5% for skinfolds and lower than 1% for girths and breadths.

Seventeen anthropometric variables were measured for each subject. Height and body mass were measured on portable set scales (models 213 and 707, Seca, Hamburg, Deutschland) to the nearest 0.1 cm and 0.01 kg, respectively. The thicknesses of 8 skinfolds (subscapular, triceps, biceps, iliac crest, supraspinale, abdominal, front thigh and medial calf) were measured using a caliper calibrated to the nearest 0.2 mm (Holtain Ltd., Crymych, UK). The sum of 6 skinfolds was also computed (subscapular, triceps, supraspinale, abdominal, front thigh and medial calf). Four girths (relaxed arm, flexed arm, thigh and calf), and 3 breadths (humerus, stylium and femur) measurements were performed using a flexible anthropometric steel tape (Holtain Ltd., Crymych, UK) to the nearest 0.1 cm. Body composition was calculated using the following models: fat mass was computed through the methods of Withers, Craig, Bourdon, and Norton [33], muscle and bone masses were determined using the methods of Lee et al. [34] and Rocha [35], respectively. According to the Kinanthropometry Spanish Committee, these methods are the most appropriate for high-performance players [36]. Mean somatotype was determined using the Heath and Carter anthropometric method [37] and its classification according to the categories by Carter and Heath [38].

2.3. Statistical Analyses

Standard descriptive statistics was used to show participant characteristics for all variables (Mean \pm SD). The Kolmogorov–Smirnov and Levene tests were applied to check sample normality. Independent samples *t*-test was used to compare anthropometric data between male and female groups with statistical significance set at $p < 0.05$. The Cohen's *d* was used as a measure of the effect size of differences between male and female players and interpreted according to Cohen's thresholds [39] modified by Hopkins [40] as small ($d = 0.2$), moderate ($d = 0.6$), large ($d = 1.2$), very large ($d = 2.0$) and extremely large ($d = 4.0$). Mean differences of selected anthropometric characteristics, body composition and somatotype components of male and female players between playing positions were tested using a one-way univariate general linear model with a Tukey post hoc test ($p < 0.05$). As in a similar study on elite team handball players [30], the decision of significance was based on eta-squared $\eta_p^2 > 0.2$ to avoid overestimation of mean differences given the small frequency of position-related cases. The Somatotype Attitudinal Mean (SAM) and the Somatotype Attitudinal Variance (SAV) was used to describe the magnitude of the absolute scatter of the group of somatotypes around each group mean for both male and female players, and for positions within each group. Likewise, the Somatotype

Attitudinal Distance (SAD) was used to compare somatotype group means of male and female players, and between positions. All statistical analyses were performed using IBM SPSS Statistics for Windows, version 22 (IBM Corp, Armonk, NY, USA).

3. Results

Table 1 shows the basic anthropometric and demographic characteristics of the sample and the results from the independent samples *t*-test between male and female players. Mean height and body mass were 187.4 ± 8.2 cm and 85.2 ± 11.3 kg for male players, and 169.1 ± 5.1 cm and 62.9 ± 5.3 kg for female players. Except for age, male players showed larger values in all characteristics than female players. These differences were statistically significant with moderate to very large effect size values.

Table 1. Anthropometric and demographic characteristics of the sample.

Variable	Male		Female		Ind. Samples <i>t</i> -Test	
	Mean \pm SD	Range	Mean \pm SD	Range	<i>p</i>	Cohen's <i>d</i>
Age (years)	27.1 \pm 5.2	20.0–37.0	24.1 \pm 4.7	17.0–33.0	0.10	0.6 (moderate)
Body height (cm)	187.4 \pm 8.2 *	169.5–202.6	169.1 \pm 5.1	160.0–177.9	<0.001	2.7 (very large)
Body mass (kg)	85.2 \pm 11.3 *	66.6–112.9	62.9 \pm 5.3	55.8–72.7	<0.001	2.5 (very large)
Arm span (cm)	192.6 \pm 12.3 *	174.5–228.0	170.6 \pm 4.7	164.4–179.4	<0.001	2.4 (very large)
BMI (kg/m ²)	24.2 \pm 2.5 *	19.5–28.8	22.0 \pm 1.5	19.8–24.5	<0.05	1.1 (moderate)
FMI (kg/m ²)	2.9 \pm 1.2	1.4–6.2	3.4 \pm 1.0	2.0–5.7	0.18	0.5 (small)

* Statistical significance between male and female players; BMI: Body Mass Index, FMI: Fat Mass Index, Cohen's *d* (Effect Size).

The three groups of anthropometric characteristics shown in Table 2 depict a general tendency for female players to have larger values of skinfolds and male players to show larger girths and breadths values, most of them statistically significant at $p < 0.01$ with moderate to very large effect size values.

Table 2. Descriptive statistics for skinfolds, girths, lengths and breadths and difference between male and female players.

Variable		Male		Female		Ind. Samples <i>t</i> -Test	
		Mean ± SD	Range	Mean ± SD	Range	<i>p</i>	Cohen's <i>d</i>
Skinfolds	Subscapular (mm)	10.9 ± 4.6	6.8–25.6	11.0 ± 6.3	7.2–31.0	0.95	0.02 (trivial)
	Triceps (mm)	7.9 ± 3.1	3.8–15.4	12.2 ± 4.0 *	5.2–21.2	0.03	1.2 (large)
	Biceps (mm)	3.5 ± 0.7	2.8–5.2	6.1 ± 2.7 *	3.4–11.6	<0.01	1.3 (large)
	Iliac crest (mm)	13.4 ± 6.4	6.2–27.5	17.2 ± 5.2	9.4–25.8	0.08	0.7 (moderate)
	Supraspinale (mm)	10.1 ± 7.8	4.0–36.2	11.0 ± 3.5	6.4–18.2	0.71	0.1 (trivial)
	Abdominal (mm)	15.1 ± 9.1	3.8–37.2	16.0 ± 4.8	8.4–26.2	0.76	0.1 (trivial)
	Front thigh (mm)	13.2 ± 5.3	5.4–21.2	26.1 ± 8.0 *	10.2–37.6	<0.001	1.9 (large)
	Medial calf (mm)	5.7 ± 2.1	3.6–10.4	13.1 ± 5.6 *	4.8–23.0	<0.001	1.8 (large)
Σ 6 skinfolds (mm)		62.9 ± 24.1	32.4–125.4	89.4 ± 24.2 *	49.3–138.8	<0.01	1.1 (moderate)
Girths	Relaxed arm (cm)	31.8 ± 3.2 *	24.4–36.2	25.1 ± 2.7	22.1–33.0	<0.001	2.3 (very large)
	Flexed arm (cm)	34.2 ± 2.9 *	27.0–37.6	26.5 ± 2.5	23.2–33.4	<0.001	2.8 (very large)
	Thigh (cm)	49.0 ± 12.6	40.6–57.7	45.3 ± 4.5	40.6–60.0	0.29	0.4 (small)
	Calf (cm)	36.7 ± 2.7 *	32.4–41.1	32.4 ± 2.0	29.0–37.1	<0.001	1.8 (large)
Breadths	Humerus (cm)	7.3 ± 0.6 *	6.2–8.2	6.4 ± 0.3	5.9–6.9	<0.001	1.9 (large)
	Styion (cm)	5.9 ± 0.7 *	5.1–7.7	5.1 ± 0.3	4.7–5.8	<0.001	1.5 (large)
	Femur (cm)	9.7 ± 1.1 *	6.2–10.5	9.0 ± 0.5	8.3–9.9	0.03	0.8 (moderate)

* Statistical significance between male and female players; BMI: Body Mass Index, Cohen's *d* (Effect Size).

Table 3 shows somatotype differences between male and female players in endomorphy and mesomorphy, with statistical significance and large effect size values. As shown in Figure 1, the mean somatotype could be defined as balanced mesomorph (2.6–4.4–2.7) with SAM = 1.85 and endomorph-mesomorph (3.5–3.3–2.6) with SAM = 1.35 for male and female players, respectively. The difference between the two groups' somatotypes SAD is 1.46.

Table 3. Somatotype components and difference between male and female players.

Variable	Male		Female		Ind. Samples <i>t</i> -Test	
	Mean \pm SD	Range	Mean \pm SD	Range	<i>p</i>	Cohen's <i>d</i>
Endomorphy	2.6 \pm 1.1	1.3–5.7	3.5 \pm 1.0 *	2.4–5.8	0.03	0.8 (moderate)
Mesomorphy	4.4 \pm 1.4 *	1.8–6.4	3.3 \pm 0.7	1.9–4.9	<0.01	1.0 (moderate)
Ectomorphy	2.7 \pm 1.3	0.6–5.7	2.6 \pm 0.8	1.2–6.4	0.81	0.1 (trivial)
SAM	1.85 \pm 1.09	0.17–3.38	1.35 \pm 0.57	0.45–2.62	0.12	0.6 (moderate)
Ponderal index	42.7 \pm 1.8	39.9–46.8	42.6 \pm 1.1	40.6–44.5	0.81	0.1 (trivial)

* Statistical significance between male and female players; BMI: Body Mass Index, Cohen's *d* (Effect Size).

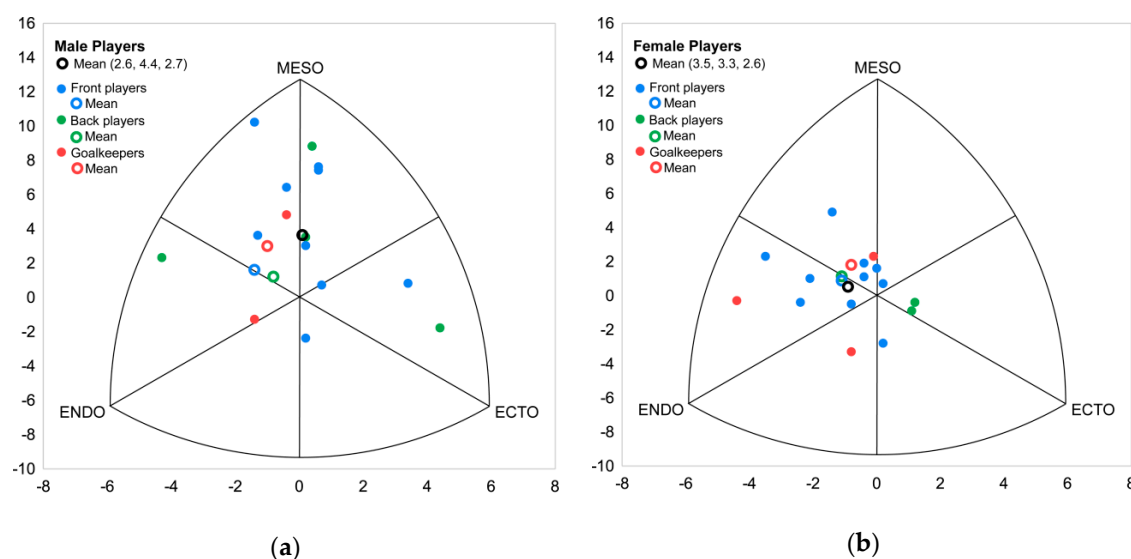
**Figure 1.** Somatocharts of beach handball players showing plots of the study sample by position and mean somatotypes (endomorph, mesomorph, ectomorph). (a) Male players, (b) Female players.

Table 4 shows that male players had greater muscular ($p < 0.01$), bone ($p < 0.1$) and residual masses ($p < 0.1$) than female players with extremely to large effect size values. Female players were characterized by larger values of body fat, although not statistically significant. The percentage values showed a similar trend to the absolute values.

Table 4. Body composition and difference between male and female players.

Variable	Male		Female		Ind. Samples <i>t</i> -Test	
	Mean \pm SD	Range	Mean \pm SD	Range	<i>p</i>	Cohen's <i>d</i>
Muscular mass (kg)	36.2 \pm 3.1 *	31.5–43.6	22.9 \pm 1.5	20.6–24.9	<0.001	5.4 (ex. large)
Muscular mass (%)	42.7 \pm 2.6 *	38.7–47.4	36.4 \pm 1.2	34.3–38.5	<0.001	3.0 (very large)
Body fat mass (kg)	10.2 \pm 4.8	5.6–24.3	9.8 \pm 2.9	5.6–16.0	0.76	0.1 (trivial)
Body fat mass (%)	11.7 \pm 3.9	6.9–21.5	15.4 \pm 3.7 *	10.1–23.2	0.01	0.9 (moderate)
Bone mass (kg)	13.3 \pm 1.8 *	10.8–16.7	9.9 \pm 0.9	8.3–11.0	<0.01	2.4 (very large)
Bone mass (%)	15.7 \pm 1.6	13.5–20.3	15.7 \pm 1.1	13.8–17.4	0.98	0.0 (trivial)
Residual mass (kg)	25.4 \pm 4.4 *	17.0–33.0	20.4 \pm 2.6	17.2–26.3	<0.01	1.4 (large)
Residual mass (%)	29.8 \pm 3.5	25.0–34.4	32.4 \pm 3.4	27.7–40.7	0.05	0.7 (moderate)

* Statistical significance between male and female players; BMI: Body Mass Index, Cohen's *d* (Effect Size).

Results in Table 5 also indicate differences in male players' position for body height ($p = 0.008$; $\eta_p^2 = 0.56$), body mass ($p = 0.016$; $\eta_p^2 = 0.50$) and arm span ($p = 0.036$; $\eta_p^2 = 0.42$). Post hoc analyses revealed that back players were taller (+12.7 cm, $p = 0.006$), heavier (+16.3 kg, $p = 0.014$) and showed larger arm span (+ 16.6 cm, $p = 0.029$) than front players. In contrast, position-related differences in female players were seen for body mass ($p = 0.007$; $\eta_p^2 = 0.57$), BMI ($p = 0.035$; $\eta_p^2 = 0.43$) and muscular mass ($p = 0.022$; $\eta_p^2 = 0.47$). Goalkeepers were the female players with the highest body mass (+ 8.8 kg,

$p = 0.010$ vs. front players; $+11.7$ kg, $p = 0.013$ vs. back players) and BMI ($+3.4$ kg/m², $p = 0.029$ vs. back players), whereas female back players showed higher muscular mass than goalkeepers ($+2.7\%$, $p = 0.021$).

Table 5. Position-related differences in selected anthropometric characteristics, body composition and somatotype components of male and female players (Mean \pm SD).

	Variable	Front Players	Back Players	Goalkeepers	ANOVA		
					F	p	η_p^2
Male players	Body height (cm)	181.4 \pm 6.4	194.1 \pm 5.7 #	187.9 \pm 2.0	7.52	0.008	0.56
	Body mass (kg)	77.1 \pm 7.2	93.4 \pm 10.7 #	88.6 \pm 0.8	5.92	0.016	0.50
	Arm span (cm)	185.2 \pm 6.2	201.8 \pm 13.9 #	191.1 \pm 3.7	4.43	0.036	0.42
	BMI (kg/m ²)	23.5 \pm 2.4	24.8 \pm 2.9	25.0 \pm 0.8	0.56	0.586	0.08
	FMI (kg/m ²)	2.4 \pm 0.6	3.3 \pm 1.6	3.3 \pm 1.0	1.02	0.391	0.14
	Σ 6 skinfolds (mm)	54.9 \pm 12.4	69.2 \pm 32.7	72.3 \pm 31.5	0.71	0.511	0.11
	Endomorphy	2.1 \pm 0.6	2.9 \pm 1.6	4.1 \pm 1.7	1.02	0.391	0.14
	Mesomorphy	5.0 \pm 1.1	4.0 \pm 1.6	3.6 \pm 1.4	1.21	0.331	0.17
	Ectomorphy	2.7 \pm 1.3	2.8 \pm 1.5	2.3 \pm 0.4	0.11	0.894	0.02
	Muscular mass (%)	43.9 \pm 2.5	41.8 \pm 2.9	41.6 \pm 0.7	1.33	0.300	0.18
Female players	Body fat mass (%)	10.3 \pm 2.3	12.8 \pm 5.1	13.2 \pm 4.4	0.84	0.454	0.12
	Body height (cm)	167.1 \pm 4.1	171.7 \pm 5.4	174.0 \pm 5.1	3.24	0.075	0.35
	Body mass (kg)	61.5 \pm 4.0	58.5 \pm 3.9	70.3 \pm 2.1 § †	7.84	0.007	0.57
	Arm span (cm)	169.4 \pm 3.9	170.5 \pm 6.7	174.6 \pm 5.5	1.59	0.244	0.21
	BMI (kg/m ²)	22.0 \pm 1.3	19.8 \pm 0.1	23.3 \pm 1.4 †	4.47	0.035	0.43
	FMI (kg/m ²)	3.3 \pm 0.8	2.4 \pm 0.5	4.5 \pm 1.1	3.71	0.056	0.38
	Σ 6 skinfolds (mm)	87.6 \pm 20.7	68.8 \pm 18.7	108.9 \pm 31.4	1.97	0.182	0.25
	Endomorphy	3.5 \pm 0.8	2.6 \pm 0.3	4.1 \pm 1.7	1.31	0.306	0.18
	Mesomorphy	3.4 \pm 0.8	2.9 \pm 0.1	3.0 \pm 0.7	0.76	0.487	0.11
	Ectomorphy	2.4 \pm 0.7	3.8 \pm 0.3	2.3 \pm 0.9	3.25	0.075	0.35
	Muscular mass (%)	36.69 \pm 1.1	37.8 \pm 0.1 †	35.0 \pm 0.6	5.35	0.022	0.47
	Body fat mass (%)	15.0 \pm 3.0	12.0 \pm 2.7	19.1 \pm 4.3	3.15	0.079	0.34

Statistical significance between Front and back players (#); Front players and Goalkeepers (§); Back players and Goalkeepers (†); η_p^2 : ANOVA's eta-squared.

As shown in Figure 1, the position-related male somatotypes resulted in mesomorph-endomorph, 3.6-3.7-2.2 for front players, (SAM = 1.7); mesomorph-endomorph, 3.3-3.5-2.5 for back players, (SAM = 2.2) and endomorphic mesomorph, 3.0-4.0-2.0 for goalkeepers, (SAM = 1.5). The differences between mean somatotypes were: front vs. back players, SAD = 0.4; front players vs. goalkeepers, SAD = 0.7; and back players vs. goalkeepers, SAD = 0.7. Besides, female players showed a mesomorph-endomorph profile for front players 3.5-3.4-2.4 (SAM = 1.2); mesomorph-endomorph for back players 3.4-3.4-2.3 (SAM = 1.6); and endomorphic mesomorph for goalkeepers 3.3-3.8-2.5 (SAM = 1.8) with differences between front and back players, SAD = 0.2; front players vs. goalkeepers, SAD = 0.4; and back players vs. goalkeepers, SAD = 0.4.

4. Discussion

The assessment of anthropometric characteristics, somatotype and body composition in beach handball players can be considered a challenging area of study due to the limited population of athletes in elite category. To the best knowledge of the authors, this is the first study providing an anthropometric reference framework for beach handball elite players and differences in body measures as a function of gender and playing positions. The strength of the present study is the high quality of the study sample, all participants being elite players from the Spanish National Selection competing at international level.

A comparison of the main characteristics: age, height, body mass, BMI, body fat mass percentage and somatotype of beach and team handball players is shown in Table 6. Anthropometric characteristics of the study sample show that male elite beach handball players show larger values of body height (187.4 \pm 8.2 cm) and body mass (85.2 \pm 11.3 kg) than female players (169.1 \pm 5.1 cm and 62.9 \pm 5.3 kg, respectively). These latter values are in accordance with those previously reported in two studies on beach handball female players from Spain: 167.87 \pm 4.42 cm; 61.04 \pm 3.98 kg, [25], 168.00 \pm 3.86 cm;

60.78 ± 3.87 kg [5] and in another two similar studies from Brazil: 169.50 ± 8.09 cm; 65.43 ± 9.44 kg [10], 168.0 ± 10.0 cm; 63.8 ± 7.1 kg [26]. Likewise, in the study of Zapardiel and Asín-Izquierdo [5], male players showed similar values of body height (187.52 ± 7.48 cm) and body mass (86.96 ± 9.53 kg) to our sample. These results are also in accordance with other team sports such as basketball [41,42], volleyball [43,44] or football [42,45], in which male players reported higher height, body mass and BMI values than female players.

According to our results, male beach handball players are shorter and lighter than their team counterparts from Spain (192.88 ± 7.60 cm and 96.88 ± 11.23 kg), and also than all other nationalities (190.10 ± 6.82 cm and 92.37 ± 9.80 kg) [46]. To the best knowledge of the authors, no similar studies have addressed the anthropometric characteristics, somatotype and body composition in beach handball players by playing position. In the field of team handball, male beach handball goalkeepers in our study show similar basic anthropometric characteristics (height, body mass and BMI) than a broad sample of players participating in a team Handball World Championships (191.89 ± 5.18 cm; 95.6 ± 10.45 kg; 25.97 ± 2.80 kg/m²) [46] and Portuguese players (189.9 ± 2.2 cm; 87.4 ± 8.7 kg; 24.5 kg/m²) [47]. However, Asian players showed similar height (186.5 ± 4.4 cm) but lower body mass (80.8 ± 7.0 kg) and therefore lower BMI (23.3 kg/m²) [48]. The same similarities can be seen between beach and team handball back players with Asian players being smaller and lighter [48]. The main difference between modalities lies in front players by which beach handball front players (wings and specialists) are as tall or taller than team handball players: 185.01 ± 5.46 cm, 184.2 ± 5.5 cm; 177.3 ± 5.0 cm but heavier and therefore with higher BMI: 84.66 ± 6.44 kg, 24.73 ± 1.49 kg/m²; 81.6 ± 7.4 kg, 25.2 kg/m²; 80.5 ± 6.1 kg, 25.7 kg/m²; [46–48], respectively. An exception can be found in wings from the first league sample showing similar height, body mass and BMI values (176 ± 4 cm, 73.9 ± 4.2 kg, 23.9 ± 1.9 kg/m²) than beach handball players of our study sample. The latter can be explained by the different demands for wings in beach handball compared to team handball. Due to the reduced playing area and the number of players (four in beach handball vs. seven in team handball), beach handball wings do not usually play as laterally as team handball wings.

Beach handball female players showed minor differences in height and body mass with respect to their Spanish team elite counterparts (171.31 ± 7.42 cm and 67.55 ± 8.06 kg) [23]. This trend can also be observed in studies comparing height and body mass in elite and sub-elite female players, with no statistically significant differences [49,50]. However, height and body mass differences were higher for Danish (175.1 ± 2.8 cm and 69.0 ± 6.2 kg) [51] or Norwegian female team handball players (179.0 ± 0.4 cm and 72.0 ± 6.3 kg) [52]. Other team sports, such as football, have also reported that Scandinavian female players are taller and heavier than Spanish female players [53,54]. Future studies should analyze the anthropometric profile of beach handball female players of other nationalities to confirm this tendency. In accordance with this, beach handball players showed lower BMI values than team handball players. Both with our study sample: 22.0 ± 1.5 kg/m² and with other elite beach handball female players from Spain: 21.68 ± 1.45 kg/m² [25] and from Brazil: 22.74 ± 2.5 kg/m² [10], BMI values were lower than female team handball players from Greece (23.6 ± 2.7 kg/m²) [19], Czech Republic (23.4 ± 2.3 kg/m²) [8]. This finding suggests that the lower values of basic anthropometric characteristics in beach handball players may play a role in the adaptation to the inherent features of the game, such as the resistance to displacement in sandy surfaces compared to court.

With regards to playing positions, our study sample showed similar values of height, body mass and BMI than Spanish team goalkeepers (174.96 ± 6.30 cm, 69.27 ± 7.66 kg, 22.60 ± 1.89 kg/m²), wings (165.49 ± 4.83 cm, 61.23 ± 4.29 kg, 22.35 ± 1.13 kg/m²) [23] and Danish back players (170.6 ± 5.0 cm, 65.2 ± 2.7 kg, 22.6 kg/m²) [51]. However, although female beach handball back players showed similar height values than the aforementioned Spanish and Danish sample of back players (174.19 ± 6.21 cm and 175.1 ± 5.3 cm, respectively), our study sample was lighter and therefore had a lower BMI than team handball back players: 71.13 ± 7.8 kg, 23.44 ± 2.32 kg/m² and 71.4 ± 6.1 kg, 23.3 kg/m².

Regarding detailed anthropometric measures, the sum of 6 skinfolds value of the female sample is in accordance with other beach handball studies (84.50 ± 20.85 mm) [25] and lower than elite team

handball players (95.50 ± 23.49 mm) [23], (92.20 ± 22.48 mm) [22]. Likewise for male players, the sum is lower than their team counterparts (77.2 ± 27.5 mm) [55]. Individual measures of skinfolds also show the same tendency by which elite team handball players show a greater amount of subcutaneous fat than beach handball.

The somatotype of our study sample showed that male players could be defined as balanced mesomorphic (2.6-4.4-2.7)—similar to team handball male players (3.01-4.85-2.29) [56] and soccer and volleyball players (1.6-4.7-2.9 and 2.0-4.0-3.2) [14]. Position-related somatotypes revealed similar mesomorphy and ectomorphy components than top-level team handball players: 4.51-2.45, 4.81-2.51 and 4.61-2.66 for goalkeepers, wings and backs, respectively [57]. The main difference lies in the endomorphy by which beach handball players show larger values for wings and backs than team handball (1.4 and 1.67), but especially for goalkeepers, who showed large differences (1.21). The larger endomorph component in goalkeepers could be explained by their more static play compared to other positions and the requirement of a large body area to cover the goal.

Beach handball female players showed a mean mesomorph-endomorph somatotype (3.5-3.3-2.6) with similar results to a study of female team handball players (3.06-2.53-2.64) [58] but fairly different to that of Greek players (4.2-4.7-1.8) [19]. Similarly to male beach handball players, position-related differences showed comparable ectomorphy components than female team handball players for the three positions, goalkeepers, wings and backs (2.72, 3.00 and 3.45) [58]. The difference with our female sample lies in the remaining components, by which endomorphy is similar to team handball: 3.50, 2.68 and 2.68 for goalkeepers, wings and backs, respectively, but mesomorphy is higher in beach handball: 3.0, 3.4 and 2.9 for goalkeepers, wings and backs, respectively. Larger levels of mesomorphy could be related to higher performance in short efforts and accelerations, which would have a positive transfer in beach handball performance [59].

In our study, male players showed body composition values lower than team handball players. Muscular mass was 36.2 ± 3.1 kg in the study sample whereas team counterparts reported 42.1 ± 7.9 kg [48] and 46.58 ± 4.25 kg [56]. Similarly, bone mass is lower in our study (13.3 ± 1.8 kg) than in the latter study on team handball. (18.02 ± 1.07 kg) [56]. Higher values of body composition components of team handball could be explained by the also higher values of weight and height discussed above. This tendency can also be observed for our female study sample with muscular mass (22.9 ± 1.5 kg) or another study with female beach handball players (22.44 ± 1.30 kg) [25] in comparison to female team handball players (25.01 ± 2.60 kg) [23]. Likewise, body fat mass percentage in our female study sample ($15.4 \pm 3.7\%$) is similar to other studies with beach handball ($14.48 \pm 3.06\%$) [25] and lower than female team handball players from Czech Republic ($21.43 \pm 2.48\%$) [8] and Greece ($25.9 \pm 3.3\%$) [19].

Our results showed that morphological characteristics should be taken into account to select players for individual positions with distinctive differences in male and female players. Professional coaches and researchers working within this specific sport should program their training strategies considering the general and position-specific tasks throughout the game. Similarly, the design of physical tests to specifically evaluate beach handball players in different playing positions could be based on the results obtained in this study, with special attention to those with large to extremely large effect sizes ($d > 1.2$).

Table 6. Summary table of studies examining age, height, body mass, BMI, body fat mass percentage and somatotype of beach and team handball players.

	Study	Level/Position	Discipline	Age (Years)	Height (cm)	Body Mass (kg)	BMI (kg/m ²)	Body Fat (%)	Somatotype
Male Players	Zapardiel et al. [5]	Spain Elite	Beach	25.3 ± 4.8	187.5 ± 7.5	87.0 ± 9.5	24.9 ^a	-	-
	Ghobadi et al. [46]	Spain Elite	Team	28.2 ± 4.0	192.9 ± 7.6	96.9 ± 11.2	26.0 ± 2.4	-	-
	Ghobadi et al. [46]	World Elite	Team	26.9 ± 4.2	190.1 ± 6.8	92.4 ± 9.8	25.5 ± 2.1	-	-
	Šibila and Pori [56]	Slovenian League	Team	25.1 ± 4.3	188.4 ± 5.5	89.6 ± 8.4	25.3 ^a	11.3 ± 2.4	3.0-4.8-2.3
	Present study	Spain Elite	Beach	27.1 ± 5.2	187.4 ± 8.2	85.2 ± 11.3	24.2 ± 2.5	11.7 ± 3.9	2.6-4.4-2.7
		Front	Beach	26.1 ± 5.5	181.4 ± 6.4	77.1 ± 7.2	23.5 ± 2.4	10.3 ± 2.3	2.1-5.0-2.7
		Back	Beach	28.2 ± 5.8	194.1 ± 5.7	93.4 ± 10.7	24.8 ± 2.9	12.8 ± 5.1	2.9-4.0-2.8
		Goalkeepers	Beach	27.5 ± 3.5	187.9 ± 2.0	88.6 ± 0.8	25.0 ± 0.8	13.2 ± 4.4	4.1-3.6-2.3
Female Players	Becerra et al. [25]	Spain Elite	Beach	22.9 ± 4.0	167.9 ± 4.4	61.0 ± 4.0	21.7 ± 1.4	14.5 ± 3.1	3.3-3.3-2.6
	Zapardiel et al. [5]	Spain Elite	Beach	25.3 ± 4.8	168.0 ± 3.9	60.8 ± 3.9	21.5 ^a	-	-
	Sena et al. [10]	Brazil Elite	Beach	26.8 ± 7.8	169.5 ± 8.1	65.4 ± 9.4	22.7 ± 2.5	22.0 ± 3.2	4.0-4.6-2.3
	Silva et al. [26]	Brazil World Champ	Beach	24.7 ± 2.0	168.0 ± 10.0	63.8 ± 7.1	-	-	-
	Vila et al. [23]	Spain League	Team	25.7 ± 4.5	171.3 ± 7.4	67.5 ± 8.1	23.0 ± 1.7	-	3.9-4.3-2.3
	Michalsik et al. [51]	Denmark League	Team	25.3 ± 6.0	175.1 ± 2.8	69.0 ± 6.2	22.5 ^a	-	-
	Ronglan et. al. [52]	Norway National	Team	23.7 ± 2.1	179.0 ± 0.4	72.0 ± 6.3	22.5 ^a	-	-
	Bayios et al. [19]	Greece League	Team	21.5 ± 4.6	165.9 ± 6.3	65.1 ± 9.1	23.6 ± 2.7	25.9 ± 3.3	4.2-4.7-1.8
	Mala et al. [8]	Check Rep. National	Team	24.0 ± 3.5	176.0 ± 6.5	72.5 ± 8.3	23.4 ± 2.3	21.4 ± 2.5	-
	Cavala and Katic [58]	Croatian League	Team	-	-	-	-	-	3.1-2.5-2.6
	Present study	Spain World Champ	Beach	24.1 ± 4.7	169.1 ± 5.1	62.9 ± 5.3	22.0 ± 1.5	15.4 ± 3.7	3.5-3.3-2.6
		Front	Beach	22.9 ± 4.5	167.1 ± 4.1	61.5 ± 4.0	22.0 ± 1.3	15.0 ± 3.0	3.5-3.4-2.4
		Back	Beach	23.0 ± 1.4	171.7 ± 5.4	58.5 ± 3.9	19.8 ± 0.1	12.0 ± 2.7	2.6-2.9-3.8
		Goalkeepers	Beach	28.7 ± 5.1	174.0 ± 5.1	70.3 ± 2.1	23.3 ± 1.4	19.1 ± 4.3	4.1-3.0-2.3

BMI: Body Mass Index, Somatotype (endomorphy-mesomorphy-ectomorphy), ^a Data computed by authors from mean height and body mass values, - = Data not available.

4.1. Limitations

The main limitation of this study is the small sample size, especially regarding positional playing subgroups. Therefore, the findings of the study should be interpreted with caution. Although being world-class elite beach handball players with very little prior research, the sample size is not powerful enough to support statements from anthropometrics and positional success for the entire population of beach handball players. Furthermore, a possible bias derived from an exclusively Spanish sample must be taken into account. The only studies with female world champion samples indicate small variations in most body measures, so the beach handball elite profile could start to converge to stable values, regardless of nationality. Still, future studies are required to confirm our results in a larger sample, particularly including other playing levels and nationalities to investigate definitive player profiles.

4.2. Practical Applications

The practical application of our study can be found in results with large (>1.2) to extremely large (>4.0) effect sizes. The most remarkable results from a practical point of view are basic anthropometric characteristics between genders (body height, body mass, arm span, and marginally BMI ($d \approx 1.2$)), which can be analyzed against other related studies in Table 6. Arm skinfolds, girths and breadths, and muscular mass are distinctive differences between male and female players. The position-related analysis revealed similar practical meaningful differences for male players (body height, body mass, and arm span) and for female players (body mass, BMI, and muscular mass) between playing positions. Results with lower d values would have needed a larger sample to provide reliable evidence. However, with the above limitations, these findings provide reference values for beach handball players that could help coaches to accurately control training to improve athletes' performance and to identify young elite players. Additionally, the data from this study can be used to design larger confirmatory studies that would expand the findings of this research. It is therefore recommended to implement anthropometric measures and somatotype determination to confirm which anthropometric factors that would contribute to performance at specific playing positions.

5. Conclusions

This study has examined anthropometric characteristics, somatotype and body composition of elite beach handball players and compare male and female players to highlight differences between groups. Anthropometric characteristics, girths, breadths, and absolute components of body composition were higher in male players than female players. Conversely, female players showed larger values of skinfolds and body fat mass percentage. The mean somatotype for male and female players was balanced mesomorph and endomorphic-mesomorphic, respectively. According to position, the optimal somatotype rating for elite beach handball players would range as mesomorph-endomorph for male and mesomorphic endomorph for female goalkeepers, balanced mesomorph for male and balanced ectomorph for female back players and ectomorphic mesomorph for male and mesomorph-endomorph for female front players. These findings provide reference values for beach handball players that could help coaches to accurately control training to improve athletes' performance and to identify young elite players. However, due to the low sample size, especially for position-related measures, further profile studies of beach handball players are required before establishing a definitive reference framework.

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